Art. XIV. *On the Influence of Physical Agents on Life.* By W. F. Edwards, M. D., F. R. S., Member of the Royal Academy of Sciences, and Royal Academy of Medicine of Paris, of the Philomathic Society of the same city, and of the Medical Society of Dublin, &c. Translated from the French, by Dr. Hodgkin and Dr. Fisher. To which are added, in the Appendix, *Some Observations on Electricity*, by Dr. Edwards, M. Pouillet, and Luke Howard, F. R. S.; *On Absorption, and the Uses of the Spleen*, by Dr. Hodgkin; *On the Microscopic Characters of the Animal Tissues and Fluids*, by J. J. Lister, F. R. S. and Dr. Hodgkin; and *Some Notes to the work of Dr. Edwards.* London, 1832. 8vo. pp. 488.

THE original of the valuable work before us was given to the world many years ago, but being composed in a foreign tongue, the important experiments and deductions which it contains were communicated but partially through the journals of the period, and as every page teems with useful and interesting information a small portion only of its contents could be laid before the profession in that way. Drs. Hodgkin and Fisher have consequently rendered a real service to the profession, by the publication of an English version. Many of the chapters were read at different times to the Academy of Sciences of Paris, and obtained for Dr. Edwards, who is an Englishman by birth, but was educated in Paris, and has resided there for the greater part of his life, the honourable distinction of the physiological prize.

"It is certainly to be regretted," says Dr. Hodgkin, "that our philosophical countryman has not himself exhibited his instructive work in an English dress, that our medical literature might have the credit of possessing it as an original rather than as a translation. Translations are generally inferior to original publications. In the present instance I have endeavoured to reduce the weight of this objection by submitting the translation to the author's perusal, and he has kindly supplied me with some fresh matter, which will be found in the Appendix. Whilst I feel justified in expressing myself as I have done with respect to the original work, to which I have to acknowledge the obligation of much important assistance in practice, I must confess myself very differently circumstanced with regard to the translation.

"To suit the convenience of English students, who have in general neither time nor inclination for voluminous reading, Dr. Fisher and myself have laboured, as far as possible, to compress the work without omitting a single experiment or conclusion. This, however, has been no easy task, as Dr. Edwards's own method of exposing the subjects of which he treats is in general too con-

cise to admit of abbreviation, without incurring the risk of producing obscurity." Preface, p. vi.

As it is not probable that the work will be republished in this country, we shall endeavour to lay before the reader such an analysis as may serve as a useful succedaneum; although it is impossible, in the space to which we must necessarily be confined, to embrace every important topic, and to elucidate it in the happy manner of the author. They, however, who seek for further information, will have to provide themselves with the work itself, which will amply repay them for the trifling outlay.

The work is divided into four parts, according to the animals experimented on:—1. *Batrachian reptiles.* 2. *Fishes and reptiles.* 3. *Warm-blooded animals:* and 4. *Man and vertebral animals.* The two last are obviously of more interest to us; but the deductions from all aid materially in solving the great problem of the influence of physical agents on animal life. We shall therefore briefly refer to the most prominent results contained in the two first parts, and dwell more at length on those classes which are more closely related to man, and on the phenomena presented by man himself.

I. *Batrachian reptiles.*—The first topic of inquiry in this class of the animated kingdom is into the phenomena of asphyxia; and especially, whether the medium, in which it may take place, has any peculiar influence independently of that which is exerted on the lungs. Of the media, the most important are air and water; and as reptiles have the power of living a considerable time after the heart has been removed from the body, the respective influence of these media can be readily appreciated. By the removal of the heart, the circulatory and respiratory functions are annihilated; the nervous and muscular systems are alone left, and these are inseparably connected. Now, by placing reptiles, whose hearts had been removed, in air and in water, and observing how long they continued to live, a comparison could be drawn of the influence of these media on the nervous and muscular systems, independently of that which they exert on circulation and respiration. This experiment was performed on salamanders, frogs, and toads.

Two salamanders, deprived of their hearts, were placed in water of the same temperature, which had been deprived of air by boiling; and two in air. One of the former died in eight hours, the other in nine; whilst those in air lived from twenty-four to twenty-six hours. The experiments were repeated with similar results; whence Dr. Edwards infers, that air, in comparison with water, has a superior vivifying in-

fluence upon the system of those animals, independently of its action by means of circulation and respiration.

Similar experiments on frogs furnished analogous results. Those in water lived two hours, those in air three.

"If a frog, thus deprived of its heart, and immersed in water, be drawn out, and exposed to the air, at the moment when all signs of life have disappeared, it immediately begins to recover. If it be again plunged in water, all appearance of life instantly ceases; and it may thus be made, several times alternately, to lose and recover its motion and sensibility." "This," adds the author, "confirms, in a striking manner, the vivifying effect of air, and the deleterious influence of water on the nervous system." p. 10.

It is more probable, however, that the effect is exerted on the contractility of the muscular fibre. Nasse has shown that water has the effect of destroying the irritability of muscles; and Dr. John K. Mitchell found, that when water was thrown into the heart of a *Testudo serpentaria*, or *snapper*, it was strongly stimulated, but its substance looked pale and hydropic, and in one minute action was destroyed beyond recovery.

In these experiments, the functions of the nervous and muscular systems alone remained; but in ordinary asphyxia, circulation continues in those animals, although respiration has necessarily ceased.

M. Edwards now attempted to ascertain the comparative duration of life in frogs whose hearts had been cut out, and in those in which they were left untouched. By placing these in water deprived of air, the latter in some instances lived twenty hours longer than the former; so that even the circulation of venous blood is favourable to the action of the nervous and vascular systems. This is strikingly illustrated in cholera, in which the activity of the nervous system, and its power over the muscles, were exemplified after nothing but dark blood was circulating in the vessels.

An interesting experiment was now made by strangling a number of frogs, by means of a ligature passed round the neck. At first they were paralyzed, but they afterwards recovered to a great degree, and lived from one to five days. The resistance to the ordinary sources of death, in the case of the amphibia, is most singular. Here we have them subsisting for days, although strangled; and Dumeril had a salamander which survived decapitation long enough for the wound to cicatrize.

It would seem, then, from the experiments of Dr. Edwards, that the batrachian reptiles can live for many days by the aeration of the

blood which is effected through the skin, and by the action of the air on the nerves distributed to the cutaneous envelope.

That the blood is acted upon by the air was satisfactorily proved by the quantity of carbonic acid exhaled from the surface of the body, when strangled frogs were placed in receivers containing atmospheric air—a fact clearly showing the existence of *cutaneous respiration* in them.

In a former number of this Journal* we referred to certain experiments that were instituted by Professor Buckland, connected with the well-known fact of the capability possessed by toads of living for a considerable length of time without air. Dr. Edwards is disposed to think, that in all the instances on record, of toads having been found imbedded in blocks of stone, there was probably some crevice, forming a communication between the external air, and the cavity containing the animal; but this, we think, is not proved. In the experiments of our author, he found that toads,—and the same remark applies to frogs and salamanders,—lived longer in sand or plaster than in air, owing, he conceives, and we think properly, to the cutaneous transpiration being more abundant in the air than in the solid substances, so that they exhaled, in the former case, the quantity of water that was necessary to their existence, and consequently expired.

In some of M. Edwards's experiments on the duration of the life of frogs inclosed in plaster, they did not survive more than six weeks; but Henissant affirms, that he kept them alive for eighteen months.

All the results of the experiments were materially modified by various circumstances, and one of the most important of these was the temperature of the medium in which the animal was placed. It was found, that as the temperature of the water of immersion was reduced, the duration of the life of the frogs was extended, until at 32° Fahrenheit, or the freezing point of water—it was more than tripled. On the other hand, the elevation of temperature caused a corresponding abbreviation of life, until, at 108° Fahrenheit, or about the natural temperature of warm-blooded animals, death was almost immediate.

"At the freezing point the animal did not become torpid, but it was less active; whilst the elevation of temperature aroused it to great agility." p. 17.

These results apply only to the asphyxiated animal. The frog, whose respiration is free, may live in warm climates in water at 108°.

It appears, too, that *season* has a manifest influence on the dura-

* For May, 1833, p. 133.

tion of life;—first, by the temperature of the water in which the animals are immersed; and secondly, by the influence of the temperature of the air for some days previous to the experiment; and when these circumstances are combined the effect is doubled.

"On the 23d Nov. 1817, the air and water being at 10° cent. or 50° Fahr. and the mean temperature of the month being nearly the same; five frogs were placed in water at the same degree. They lived from 5h. 10′ to 11h. 40′; the latter period being about double the duration of life of these animals in water at the same degree in summer. On the 22d Dec. the thermometer having been about 0° cent. or 32° Fahr. for twenty days, three frogs were put in water at 10° cent. or 50° Fahr.; they lived from twenty to twenty-four hours. On the 23d Dec. the temperature being still 0° cent. or 32° Fahr. four frogs were placed in water at 0° cent. or 32° Fahr. the same apparatus being employed as in the preceding experiments. They lived from twenty-four to sixty hours." p. 20.

In the last experiment, consequently, they were placed in circumstances the most favourable for the prolongation of life under water.

The adult batrachians have only lungs,—organs adapted exclusively for atmospheric respiration. It becomes an interesting question, therefore, to inquire how they are influenced by the air contained in water, and whether they are not compelled, both in summer and winter, to come to the surface to breathe. M. Bosc informed Dr. Edwards, that he has seen the frog, during the winter season, quit the water for several days in succession, at a certain hour, and take breath for a short time on land; and if this be necessary in winter, when the animal is less active, it must be still more so in summer.

To prove how far they are really influenced by the air contained in water, our author first tried the effects of limited quantities of water; and he found that frogs lived from three huurs and forty minutes to five hours and thirty minutes in boiled water, whilst others, in aerated water of the same temperature, lived from six hours and forty-three minutes to ten hours and forty minutes;—results which showed that the air in the water has a decided influence in prolonging the life of these animals within certain limits.

Another experiment proved most satisfactorily that frogs are truly amphibious, or capable not only of breathing the air of the atmosphere, but also of living exclusively on the air contained in water. By daily renewing stagnant water, a male frug, secured at the bottom of a glass vessel, was kept alive for more than two months and a half. Tadpoles can live in water without coming to the surface. They have, however, gills as well as lungs, and hence resemble fishes. They differ from the frog in not being able to live on land previous to the full development of their limbs.

The air contained in the water does not seem to act through the medium of the lungs. Inspiration in frogs is performed by a kind of deglutition, and is accompanied by very evident movements of the throat. In the atmosphere, these movements are repeated thirty or forty times in a minute; but when the animal is plunged in water they cease, and are not repeated; and if the lungs of the frog be examined no water is found in them, even when the immersion has been prolonged. The air must consequently act on some other organ than the lungs; and the skin is the only other organ in contact with the fluid.

The experiments, previously referred to, having established the fact of cutaneous respiration in the batrachians, Dr. Edwards next attempted to discover, whether these animals could continue to live, if permitted to breathe by the lungs alone, the atmosphere being altogether excluded from contact with the skin; and he inferred from his experiments, that—

"Pulmonary respiration is not sufficient to support the life of tree frogs, without being accompanied by the atmospheric influence upon the skin. The case is the same with the *rana obstetricans*, on which the experiment was also tried, and we may conclude, that the observation applies to all the batrachians. p. 41.

The attention of Dr. Edwards was next directed to the influence of the atmosphere on the *perspiration* of those animals. This he found to depend greatly upon the condition of the animal as to saturation; and accordingly the loss by perspiration differs greatly; but, taking the animal at the point of saturation or fulness, it is found to lose less and less by perspiration in a given time, in proportion as it removes from this point.

The quantity lost was found to depend greatly on the state of the atmosphere, as to rest and motion: when the wind was strong, the perspiration was quadrupled. It was to be expected likewise, that it should differ according to the hygrometric state of the atmosphere. Air, saturated with moisture, did not seem to prevent perspiration altogether, although it reduced it to its minimum. We do not think, however, that Dr. Edwards's experiments on this point were altogether satisfactory. The animal was suspended in a glass vessel, inverted over water, in which it would by no means follow, that the air should be saturated with moisture. The function of transpiration being one of depuration, must of necessity go on whether the air is saturated or not. In dry air, the loss was from five to ten times greater than in air of extreme humidity, according to the degree of dryness and the duration of the experiment.

As to the relative influence of different degrees of temperature upon the quantity of perspiration, it was much less than was anticipated. During five hours, the quantity perspired at 68° Fahr. was scarcely twice what it was at 32° Fahr. and that at 104° Fahr. was seven times greater than at 32° Fahr.;—thus resembling the effects obtained from a dry and still, compared with a humid atmosphere.

Another important topic of inquiry was, how the weight of the body is influenced by the contact of water with its external surface? That water was absorbed was manifest, and the weight of the body was found to increase or diminish, according as either of the antagonist functions of absorption and transudation exceeded the other. At 32° Fahr. the absurption predominated; at 86° the transpiration. Thus much, as regards the batrachian reptiles.

II. *Fishes and reptiles.*—The first stage of the life of batrachian reptiles, or the tadpole state, is so peculiar as to have induced the author to consider it under this head. The chief peculiarity consists in their possessing two kinds of respiratory organs—lungs and gills.

"Tadpoles unite in regard to respiration, the functions of reptiles with those of fishes; their use of them varies, not only according to their development, but also according to their physical conditions, under the influence of which we are now about to consider them. The tadpole has, in common with the adult animal, the power of supporting life through the medium of the skin, by means of the air contained in water. It has already been shnwn, that the limits of temperature in which the adult animals are able to exist, are 32° and 50° Fahr. or 0° and 10° cent.; and that beyond the higher limit, the greater part were obliged to have recourse to atmospheric respiration; but tadpoles, having an additional organ, by which they are enabled to avail themselves, in a higher degree, of the vivifying influence of the air contained in water, ought, we would imagine, to support, under water, a much greater elevation of temperature, without having recourse to the external air. That this is actually the case, is shown by experiments in which they were kept a long time in vessels with the water occasionally changed, and in running water, at the temperature of 25° Cent. or 77° Fahr." p. 52.

The most important of Dr. Edwards's inquiries was into the influence of physical agents on the transformation of the tadpole into the frog. This is known to be expedited by a due supply of nutritious matter, and to be retarded when the supply is scanty.

The effect of temperature is also signal. If the tadpole is produced late in the summer, the subsequent temperature not being sufficiently elevated, it passes the winter in the larva state, and does not quit it until the return of warm weather. The results of the experiments, instituted by our author, further showed, that if deprived of atmospheric respiration they would retain their original form under water,

if their nutriment were not too abundant, and the temperature were not too high; and that the difference of atmospheric respiration alone, joined to these circumstances, would determine the transformation. It will be seen afterwards, that privation of light has a great effect in retarding and modifying their development.

Experiments were made on *fishes* similar to those on the batrachian reptiles; and first, as regards the influence of temperature on their lives in water deprived of air. Comparative experiments were made on individuals of the same species, at temperatures varying from 32° Fahr. to 104°. The result was, that at the higher limit death was as speedy as in the case of the batrachians, and the duration of life was progressively greater in proportion as the temperature was reduced to the lower limit. It appeared, however, that the smaller and the younger the fish, the less capable was it of bearing an elevation of temperature. At 104° the small fish do not live more than two minutes, whilst the larger survive several minutes longer. These results only apply, however, to the case of fishes inhabiting water of the ordinary temperature of the climate. De Saussure, Sonnerat, Bruce, Abel, Lamarck, and others, sufficiently show, that these animals may breed, and live in water of a much more elevated temperature. Humboldt and Bonpland saw them thrown up alive fro the bottom of a volcano, the steam of which raised the thermometer to 210° Fahr.

His next inquiry was into the *influence of the temperature of aerated water in limited quantities in close vessels*, and from a number of experiments he deduced the following inferences; *first*, that the duration of life goes on increasing with an increase of the quantity of aerated water, the temperature remaining the same; *secondly*, that the same result takes place when, the quantity of water remaining the same, the temperature is lowered; and *thirdly*, that the duration of life remains the same, when, within certain limits, we increase or diminish at the same time both the temperature and the aerated water. p. 57.

The influence of temperature on fishes was found to resemble that on the batrachian reptiles. If a bleak *(Cyprinus alburnus)* be put into a vessel with a large mouth, containing five ounces and a half of aerated water, at 68° Fahr., in summer, it dies within a few hours; but when the temperature is lowered to 50° or 53° Fahr. and is kept at that point, the animal lives until its secretions are so abundant as to corrupt the water; and if the water be renewed every twenty-four hours, it lives in it almost indefinitely.

From all his experiments connected with this subject, the author

deduces, that the more the temperature is raised beyond certain limits, the greater is the degree of influence of the air required for their support.

The experiments of SYLVESTRE and others had sufficiently shown, that atmospheric respiration has an influence on the life of fishes—that it tends to prolong their existence in water. It became interesting, however, to examine into the circumstances connected with their life in the air. When a fish is taken from the water, it dies in a few minutes, or in a few hours, according to the species; and hence it has been inferred, that fishes are incapable of living by atmospheric respiration, or that air in this form is unfit for their continued existence. From a series of well-devised experiments, it was further shown—

"That the life of fishes in the atmosphere depends on several conditions, of which the principal are, temperature; the capacity of saturation with water; the corresponding loss by perspiration from the trunk and gills; the quickness of this loss; the action of the muscles which move the gills; and the use which they make of their muscles to avail themselves of the action of the air upon the gills. In short, they come under the general law relative to the influence of the atmosphere on the life of vertebrated animals. As fishes seem to form an exception to this law, I have thought it necessary to show that they are so only in appearance. What has been here stated relative to the life of fishes in the atmosphere, is equally applicable to tadpoles, placed in the same circumstances. They die from the quantity of water which they lose by perspiration; and although their capacity of saturation is, at least, equal to that of frogs, since it varies between one-third and one-fourth of their weight, yet as their size is very small, and their perspiration rapid, on account of the delicacy of their skin, they soon lose that proportion of water, and in the experiments which I made, I found that they did not live more than four hours." p. 64.

Similar experiments were made on lizards, serpents, and tortoises; in other words, on the saurian, ophidian, and chelonian reptiles, which showed, that as regards the action of the atmosphere, the general results are the same with all cold-blooded animals: modified, however, by the character of the external covering, as respects its porosity and thickness.

III. *Warm-blooded animals.*—This and the fullowing part are possessed of more interest to us than those to which we have attended, and are more calculated to aid us in determining many important topics of physiological and pathological inquiry. The first chapter is on the *heat of young animals.*

It has been a universal opinion, owing to the circulation of young animals being more rapid, and the function of nutrition more active, that their temperature is much higher than that of adults. The opinion is not sanctioned by observation. When new-born animals are

examined, the temperature, if placed near the mother, is never found to be superior to that of the adult. But if when the temperature is from 50° to 68° Fahr. a new-born puppy be removed, and kept an hour or two from its mother, the temperature falls considerably, and continues falling, until, in the course of three or four hours, it stops at a very few degrees abuve that of the surrounding air. The heat begins to subside as soon as the separation takes place, and the diminution is not in the least retarded by furnishing the animal, from time to time, with milk. So that it would appear, from these and other experiments, that the young animal, of certain species at least, produces less heat in a given time than the adult. As it advances in life, the diminution, under the circumstances mentioned, takes place more slowly, and to a less and less extent; until, at the end of a fortnight, it will maintain itself at a degree nearly equal to that of the parent. The new-born puppy would seem, consequently, to resemble the cold-blooded, rather than the warm-blooded animal, the characteristics of the latter being acquired gradually.

The same phenomena were found to take place with kittens and rabbits, but not with the young of all the mammalia—with the young Guinea-pig for example. The young of the mammalia seem, therefore, to be divided into two groups, in relation to animal heat; some being born, as it were, cold-blooded; others warm-blooded.

Now, corresponding to this difference, there appears to be another, deducible from the state of the eyes. Some are born with the eyes closed; others with them open; and until the eyes are opened they resemble the cold blooded-animal; those that are born with the eyes open being warm-blooded from birth.

"Thus," says Dr. Edwards, "the state of the eyes, though having no immediate connexion with the production of heat, may yet coincide with an internal structure influencing that function, and certainly furnishes signs which serve to indicate a remarkable change in this respect; since, at the period of the opening of their eyes, all young mammalia have nearly the same temperature as adults." p. 70.

Analogous results were obtained in the case of young birds,—the experiments being all admirably arranged, so as to prevent the existence of any source of fallacy,—but here again a difference was perceptible in different birds, some being, like the young Guinea-pigs, capable, as soon as they are extruded, of maintaining an elevated temperature, if exposed to the air in a favourable season. None, however, have the power of preserving their temperature, when the season is very severe, owing to the young possessing to an inferior degree the power of producing heat.

We may conclude, then, that the power of producing heat, in warm-blooded animals, is at its minimum at birth, and increases successively, according to our author, until adult age.

The singular phenomena of *torpidity*, which has engaged the attention of so many physiulogical naturalists uf eminence, could not fail to attract that uf Dr. Edwards. The hibernating animals—as the bat, hedgehog, dormouse, garden dormouse, and the marmnt, possess all the characteristics of the mammalia, and are distinguished from the others only by their hibernation; during the existence of which they are converted, for the time, into cold-blooded animals;—their temperature being scarcely higher than that of the surrouoding utmosphere; their respiratory movements irregular, feeble, aod at long intervals; and no nourishment being taken during the whulc period, which continues for several months.

The attention of observers—of Spallanzani, Hunter, Mangili, De Saissy, aod others—has been priucipally bestowed on these auimals during the period of hibernation; upon the mode of resuscitating them, as it were, and of again throwing them into torpidity. The researches of M. Edwards were directed chiefly to the phenomeoa connected with their temperature, which seem to influence all the others.

The spring and summer temperature of these animals has been found equal to that of many other mammalia, 98°.6 of Fahr.; but the followiog experiment of M. Edwards, essentially resembling some performed by M. De Saissy, shows that they produce less heat.

In April, 1819, the air being at 61° Fahr. an adult bat, of the long-eared species, recently taken, in good condition, and at the temperature of 93° Fahr. was placed in an earthen vessel, which was cooled by a mixture of ice and salt, till the air within was reduced to 33°.8 Fahr. The vessel had a cover, which alluwed a free cummunication with the external air. After the animal had been there for an hour, its temperature was reduced to 57° F.;—a loss in this short space of time of 36° F. Guinea-pigs and adult birds, placed in the same circumstances, lost, at the utmost, nut more than two or three degrees, although the influence of the cold was prolonged, in their case, to compensate for the difference of size.

Hence it appears, that bats produce less heat than animals which do not hibernate. To this cause must be ascribed the reduction of their temperature during the cold season; and it applies to all hibernating animals as well as to the bat.

From this ioquiry the transition was natural to that,—whether in the opposite seasons of winter and summer, warm-blooded animals,

not hibernating, presented any difference in regard to their power of producing heat? This was to be ascertained by placing animals of the same species in the same conditions of refrigeration in winter and summer, and observing whether their temperature diminished unequally.

"It is necessary," says M. Edwards, "in the first place, that the animals selected should be as similar as possible, and that the experiments should be sufficiently numerous to obviate any considerable influence from individual diversities. In order that the mode of refrigeration should be the same, attention must be paid, not only to the temperature, but to the humidity of the atmosphere; for a difference in the hygrometric state of the air would produce a corresponding difference in the evaporation from the lungs and skin, and consequently in the quantity of heat lost.

"The apparatus consisted of glass vessels, of the capacity of two pints, placed in a freezing mixture of salt and ice. The air, thus cooled, is at its point of saturation with moisture. When it is at zero cent. or 32° Fahr. the animal is introduced, and placed on a false bottom of gauze, to prevent the contact of the cold glass. A lid covered with ice is placed over the vessel, but so as to permit change of air for the free exercise of respiration; and, in order more effectually to secure the purity of the air, a concentrated solution of caustic potass is placed at the bottom, to absorb the carbonic acid, which it readily does, through the gauze." p. 82.

The general results were as follows:—In the month of February the experiment was made, at the same time, upon five adult sparrows. In the course of an hour, they lost, on an average, 7°.2 Fahr., some having lost none; others only 1°.8 Fahr. Their temperature then remained stationary, until the end of the experiment, which lasted three hours. In July the same experiment was tried on four others. Their temperature, in the course of the first hour, sustained an average loss of 6°.5 Fahr.; at the end of the third hour the average reduction from their original temperature was 10° Fahr. In another series of experiments on six sparrows, in the month of August, the mean loss of temperature, at the end of the first hour, was 2°.9; and after three hours 8°.76:—experiments which would seem to show, that continued elevation of temperature diminishes the power of producing heat, whilst an opposite state of the atmosphere, provided the cold be not too severe, increases it.

The hope of producing such a change in animals as might enable them to support the privation of air for a much longer period than is natural to them, and to become aquatic animals, led Buffon to the discovery of a singular fact connected with young animals. He placed a greyhound bitch, of the large species, when on the point of giving birth to young, in a tub of warm water, and secured her in

such a manner that she was obliged to bring them forth under water. These were afterwards, for the sake of nourishment, transferred to a smaller tub of warm milk, but without giving them time to breathe. They remained there for above half an hour, after which they were taken out, and all found alive. They began to breathe, which they were permitted to do for half an hour, and were then again plunged in the milk, which had been warmed again in the mean time. There they remained for another half hour, and when they were again taken out, two were quite strong, and seemed not to have suffered at all. The third appeared drooping, but was carried to its muther, and soon recovered. The experiment was continued on the other two: they were allowed to breathe a second time for about an hour; and were then plunged once more in the warm milk for half an hour, after which they appeared as strong as before. Being taken to their mother, however, one of them died the same day, whether by accident, or from the privation of air, could not be ascertained. The other lived as well as the first; and both throve as well as the other puppies produced after the bitch was removed from the water, and which had not been experimented upon.

Some similar experiments were made by Le Gallois on rabbits, which would favour the belief, that the duration of the life of new-born mammalia, under such circumstances, is about half an hour. Yet M. Edwards was surprised to find, that the Guinea-pig, at birth, when plunged in water, lived only three or four minutes longer than the adult, and in other animal species the difference was not greater. On inquiring into the causos of this difference, he found that those animals which, when asphyxiated, give signs of life for half an hour, are the very species that possess feeble powers fur the production of heat—new-born dogs, cats, and rabbits, fur example. It was before observed, that these animals, at this period of existence, strongly resemble fishes, and these facts show that they resemble them further in the power of sustaining privation of air. On the other hand, Guinea-pigs are in the class that produce most heat at birth, and of these the author says he has never seen one which lived above seven minutes under water.

"We have seen," says M. Edwards, "that at the end of the fifth day the duration of life during asphyxia is reduced one-half: now this reduction corresponds to a sensible elevation of their temperature. The same is the ease after the second interval of five days; the heat is then much increased, and the power of living without respiration is considerably diminished. Lastly, when they have arrived at the fifteenth day, a period when they usually have a temperature nearly equal to that of adults, they scarcely differ from them in the duration of

asphyxia. If, instead of passing at once from the first to the fifth day, we examine the young animals in the intervening days, we shall find, that during the first and second, and even not unfrequently the third, the duration of asphyxia is only very slightly altered. The production of heat corresponds with this, and both phenomena likewise concur in the more rapid and striking change that quickly after takes place.

"We see that the distinction formerly pointed out between young mammalia, founded in the production of heat, is applicable to them, also, in respect to the duration of life, when deprived of respiration. This duration has its maximum in the group of mammalia which produce the least heat at birth, and its minimum in those which produce the most." p. 88.

The external temperature has likewise an influence on the duration of asphyxia in these cases. Some kittens, when a day or two old, were subjected to water, cooled to 32° Fahr.; they ceased to give signs of sensibility and motion after four minutes and thirty-three seconds, taking the mean of nine experiments. At a temperature of 50° Fahr. the duration of life extended to ten minutes and twenty-three seconds; at 68°, to thirty-eight minutes and forty-five seconds. At 86°, however, they lived but twenty-nine minutes, and at 104°, but ten minutes and twenty-seven seconds;—so that there are two principal conditions which influence the life of warm-blooded animals when deprived of air; namely, the quantity of heat developed by the animals themselves, and the external temperature to which they are exposed.

In his experiments upon the respiration of this class of animals, M. Edwards found that the young are capable of living much longer than the adult in the same quantity of air; and consequently, that their consumption of the air in respiration is comparatively less. So that the adult animal, whose power of producing heat is great, consumes more air than the young animal, whose calorific powers are less. Here, again, a difference existed between Guinea-pigs and puppies. The latter were removed from the confined space at the end of four hours and fifty-nine minutes, the former after an hour and forty-two minutes. A recollection of the fact, that young puppies at birth produce much less heat than Guinea-pigs, will explain the apparent anomaly.

It was before remarked, that the power of producing heat in warm-blooded animals, is greater in winter than in summer; and the experiments of M. Edwards showed that the consumption of oxygen is more rapid in the former season.

The researches of our author on the *perspiration* or *exhalation* of warm-blooded animals, led him to the following results:—

"That the successive losses by perspiration are subject to considerable varia-

tions and alternations of increase and diminution, when compared at short intervals, but constantly decrease when considered at longer periods. The periods during which the fluctuations takes place in vertebrated animals generally, may be pretty accurately determined. We have always observed, in warm-blooded animals, the alterations to take place with intervals of an hour, and this term may be regarded as a general rule. On examining the whole series of experiments upon vertebrata of different classes, it was observed that the shortest intervals within which the successive diminution took place were those of two hours, and the longest, nine. In taking a mean of six, we may hope to include almost all the cases, for even when a longer space of time was necessary, three hours were sufficient to determine a diminution, if not constant, at least with little variation. In the greater number of cases, it took place in successive intervals of three hours." p. 105.

The main results were found to be conformable to those obtained on cold-blooded animals. In the former, however, the perspiration was found to be six times greater in dry than in moist air. The influence of air in motion, and air at rest, on the function of perspiration, was found tu be analugous to that experienced in the cold-blooded animal.

IV. *Man and vertebrate animals.*—The effect of various physical influences on these upper classes of created beings are of most moment to us, although nothing can be more instructive to the scientific anthropologist than an investigation of similar influences on animals lower in the scale; from which, by invoking a wise analogy, inferences may be drawn that tend largely to elucidate many obscure phenomena presented by man himself.

"The results," says our author, "obtained in my experimental inquiries into the influence of physical agents on other warm-blooded animals have been so uniform, that they may, by analogy, be extended to man, although he can scarcely be made the subject of the experiments themselves, and for this reason was not mentioned in the preceding part." p. 112.

The first chapter of this division is *on the modifications of heat in man, from birth to adult age;* and here we observe, at once, the striking analogy to the warm-blooded animals in general. It was before stated, that those which are born with the eyes closed, lose their heat when they are exposed to the air in spring or summer, almost as rapidly as cold-blooded vertebral animals; whilst those whose eyes are open at birth, under similar circumstances, preserve a high and constant temperature. In accordance with analogy, a new-born infant, at the full period, having the eyes open, should have the power of maintaining a pretty uniform temperature during the warm seasons; but if birth takes place at the fifth or sixth month, the case

is altered; the pupil is generally covered with the *membrana pupillaris*, which places the animal in a condition similar to that of closure of the eyelids in other animals. Analogy would induce us to conclude, that in such an infant the power of producing heat would be inconsiderable. Observation confirms this; although we obviously have not the same facilities, as in the case of animals, of exposing the young to a depressed temperature. On taking the temperature of twenty adults, it was found to vary from 96° to 99° Fahr. the mean being 97°; whilst the temperature of ten healthy infants varied from 93° to 95° Fahr. the mean of the whole being 94°.55.

The temperature of a seven months' child, though well swathed, and near a good fire, was, within two or three hours after birth, no more than 89°.6 Fahr. Before the period at which this infant was born, the *membrana pupillaris* disappears; and it is probable, as Dr. Edwards has suggested, that if it had been born some time before the disappearance of the membrane, its power of producing heat would have been so feeble, that it would scarcely have differed from that of mammalia born with the eyes closed.

These facts suggest another most important object of inquiry, regarding the *influence of cold on mortality at different periods of life.* If the faculty of evolving heat differs, vitality will be correspondingly modified; and the temperature of the atmosphere has to be guarded against by proper precautions, especially where the capability of evolving heat is feeble.

Now, as this capability is less in the infant at birth than it is subsequently, it requires the assistance of external warmth more than it does subsequently, and it is probable that contact with the mother, so strongly suggested by the maternal feelings and instincts, is essential to the due maintenance of the vital energies.

The following experiments are full of interest in this point of view.

"On 12th February 1819, a kitten, newly littered, removed from its mother, and exposed to the air, at the temperature of 14° cent. or 51° Fahr. being cooled down in nine hours to 18° cent. or 64°.4 Fahr. became stiff, and almost incapable of executing the slightest movements.

"The following month the air of the room being 10° cent. or 50° Fahr., I exposed two kittens, of one day old, and having a temperature of 37° cent. 98°.6 Fahr. In 2h. 25, the temperature of one was reduced to 17° cent. or 62°.6 Fahr. and that of the other to 18° cent. or 64°.4 Fahr. They had become stiff and almost insensible.

"In the month of January in the same year, four puppies littered the day before, were of the temperature of 35° to 36° cent. or 95° to 97° Fahr. The air of the room was 11° cent. or 52° Fahr. The cooling which they underwent

from nine in the morning till ten at night, lowered their temperature to 13° and 14° cent. or 55°.4 and 57° Fahr. They were then so enfeebled that they were almost motionless.

"The symptoms of weakness and suffering soon after the young animals are exposed to the air, increases as their temperature sinks. The same circumstances occur with those young birds which produce the least warmth when hatched.

"Although the diminution of temperature thus occasioned by exposure to the air, would ultimately prove fatal to these young animals, it is remarkable how long they are capable of enduring a considerable reduction of temperature. New-born puppies or kittens may live two or three days at a temperature of 20° cent. or 68° Fahr. and even 17° or 18° cent. or 62°.6 or 64°.4 Fahr. But the air must not be too cold, or they would soon be deprived of sense and motion, and in a short time this apparent death would become real. When they appeared on the point of expiring, I easily restored animation by placing them before the fire or by immersion in a bath. These means, if promptly applied, may even prove effectual when they are quite motionless, and, to all appearance, dead." p. 119.

It appears, then, that these animals bear a considerable reduction of their temperature, but they must not be left too long in the state of reduction; and due care must be taken in the restoration of warmth. If the exposure be too often repeated, or too long continued, it is fatal; and the facility of recovery after great reduction of temperature, does not continue in the same degree in the progress of life. The reduction of bodily temperature is therefore less injurious in its permanent effects, in proportion to the youth of the animal.

It has been observed, that in young warm-blooded animals, the capability of supporting reductions of temperature is inversely proportionate to their power of producing heat, and this appears to be a wise provision of nature; for whatever care may be taken by parents of their young, they cannot always remain with them to maintain their temperature at a high degree, if they belong to the class of animals that are born with closed eyes, or without feathers.

"As soon as they leave them to provide subsistence, the temperature of their young begins to be reduced, and if this reduction were as injurious as it is to those animals which produce more heat, the greater part would perish." p. 121.

The following is a general review of the facts relative to the influence of cold at the different periods of life.

"We must distinguish two things—the cooling of the body, and the temperature capable of producing it. The cooling of the body, without regard to its cause, is less injurious in proportion to the youth of the animal. Lower the temperature of two animals of the same species an equal number of degrees, the young will suffer less, and will recover more perfectly. But, in order to lower the temperature of animals of different ages, different degrees of external

cold will be necessary, being lower, the nearer the animal is to adult age. If, on the other hand, young animals suffer less from the same reduction of warmth, on the other hand, they cool more readily. It is on this last circumstance, that the mortality in warm-blooded animals, at different periods of life from birth to adult age, principally depends, so far as it is the result of the influence of external cold." p. 122.

When the momentary application of cold is frequently repeated, the power of producing heat becomes enfeebled, and it takes some time for the organs of calorification to recover their power: on the other hand, after exposure to cold sufficient to diminish the power of producing heat, continuance in a high temperature tends to the recovery of this power, for on exposing animals to successive applications of cold, their temperature is found to fall the more slowly the longer they have been subjected to the influence of warmth. Hence, persons who are liable to frequent exposure to severe cold, are rendered more capable of supporting it, by subjecting themselves, in the intervals, to an elevated temperature. The transient application of heat consequently occasions effects, which are continued beyond the time of the application, and it operates whenever the system stands in need of heat.

The experiments of Le Gallois, as well as those instituted by himself, have induced M. Edwards to infer, that there is always a certain ratio between heat and respiration in both the cold-blooded and warm-blooded animals; and in hibernating animals both in the periods of torpidity, and of full vital activity. When the eighth pair of nerves is cut in the young of the mammalia, a considerable diminutiun is produced in the opening of the glottis, so that in puppies, recently born, or one or two days old, so little air enters the lungs, that when the experiment is made in ordinary circumstances, the animal perishes as quickly as if it was entirely deprived of air. It lives about half an hour. But if the same operation be performed upon puppies of the same age, benumbed with cold, they will live a whole day. In the first case, the author thinks, and plausibly, the small quantity of air is insufficient to counteract the effect of the heat; whilst in the other, it is sufficient to prolong life considerably; and he deduces the following practical inferences applicable to the adult age, and particularly to man.

"A person is asphyxiated by an excessive quantity of carbonic acid in the air which he breathes; the beating of the pulse is no longer sensible, the respiratory movements are not seen, his temperature however is still elevated. How should we act. to recal life? Although the action of the respiratory organs is no longer visible, all communication with the air is not cut off. The air is in contact with the skin, upon which it exerts a vivifying influence; it is also in

contact with the lungs, in which it is renewed by the agitation which is constantly taking place in the atmosphere, and by the heat of the body which rarifies it. The heart continues to beat, and maintains a certain degree of circulation, although not perceptible by the pulse. The temperature of the body is too high to allow the feeble respiration to produce upon the system all the effect of which it is susceptible. The temperature must then be reduced, the patient must be withdrawn from the deleterious atmosphere, stripped of his clothes, that the air may have a more extended action upon his skin, exposed to the cold, although it be winter, and cold water thrown upon his face until the respiratory movements reappear. This is precisely the treatment adopted in practice to revive an individual in a state of asphyxia. If instead of cold, continued warmth were to be applied, it would be one of the most effectual means of extinguishing life. This consequence like the former, is confirmed by experience.

"In sudden faintings, when the pulse is weak or imperceptible, the action of the respiratory organs diminished, and sensation and voluntary motion suspended, persons the most ignorant of medicine are aware that means of refrigeration must be employed, such as exposure to air, ventilation, sprinkling with cold water. The efficacy of this plan of treatment is explained on the principle before laid down.

"Likewise in violent attacks of asthma, when the extent of respiration is so reduced that the patient experiences suffocation, he courts the cold even in the most severe weather, he opens the windows, breathes a frosty air, and finds himself relieved." p. 149.

As a general rule, an elevated temperature accelerates the respiratory movements, but the degree of temperature requisite to produce this effect, is not the same in all. The object of this is, that more air shall come in contact with the lungs in a given time, so as to reänimate what the heat depresses.

In young animals, especially such as are born without the power of maintaining their temperature in the open air, as soon as they are exposed to cold the respiration increases in rapidity and extent, and their temperature begins to fall. They present, according to our author, the phenomena of an attack of *febris algida*, and this state is quickly fatal, if not remedied by renewing the heat of the body.

"Although the acceleration of respiration is a powerful means of counteracting the effects of cold, by extending the contact of the air with the organs best adapted to feel its vivifying influence, this acceleration has its limits: it may diminish, but cannot compensate for the effects of excessive cold.

In the progress of life, however, these young beings are less and less affected in their respiratory movements by the same temperature, until it ultimately has no influence over them, so that in adult age, the rapidity of their respiratory movements is much less subject to be influenced by external temperature: yet in them, if the cold be carried sufficiently far, an acceleration takes place in the respiratory

movements, until, the powers being exhausted, these movements, like all the others, languish, and fail.

From these and other facts, it would seem to follow, that when an individual experiences a change of constitution, which diminishes his production of heat, or consumption of air, he cannot endure that degree of cold, which previously would have been salutary to him, without experiencing, sooner or later, an alteration in the rate of his respiratory movements.

"Hence the necessity, when these two functions have experienced this alteration, as in cases of organic affection of the heart and lungs, of placing the patient in communication with a milder temperature, either artificially, or by change of climate." p. 156.

If an individual be kept quiet, and abstain from food, and sleep, his *perspiration* may be regarded as uniformly diminishing in each succeeding period of six hours:* in some a longer period may be necessary, in others a shorter. In some, M. Edwards thinks, successive diminution of perspiration may be observed in periods of three hours, but this he considers to be the minimum. The period of the greatest perspiration, when no obstructing cause exists, is generally, according to him, from the hour of rising in the morning—say six o'clock—till noon, and the losses are successively less in similar intervals, for the remainder of the twenty-four hours.

The hygrometric condition of the atmosphere, the state of motion and rest of the air, and the pressure of the atmosphere, have the same influence over this function in man as in animals.

Dr. Edwards, however, considers that these conditions affect only the insensible perspiration, or that which is produced by *evaporation;* but they do not produce sweat, which he regards as a process of *transudation;* thus making, with Haller, the insensible and sensible perspirations two distinct functions, although it appears to us there is not sufficient ground for the distinction. The insensible perspiration he looks upon as a purely physical phenomenon, whilst the sensible "is a loss ordinarily produced by a vital action, in the form of a liquid which transudes;" but even were we to admit the difference, the altered characters of the air might exert a decided effect on the cutaneous capillaries that are charged with the secretion. If the air, for example, be loaded with moisture, the perspiration cannot pass off, but accumulates on the surface, and under such circumstances it

* These periods are chosen to obviate the influence of the constant fluctuations that are observed in the amount of the perspiration at short intervals.

is probable, that the activity of the vital operatiun would be less than where it can readily be exhaled as it is formed. The vessels of the skin we regard as depuratury organs, like the kidneys, and we think this applies to them as organs of the insensible as well as of the sensible transpiration. It cannot be denied, however, that a certain extent of evaporation of fluids may take place in the living as well as in the dead body, and the loss, produced in this way, must be added to that experienced through the function of perspiration.

On the effect of suppression of perspiration M. Edwards expresses himself in a rational and sound manner. It has always appeared to us, that this has been too blindly invoked as a cause of disease; and that the morbid influence, in such cases, is rather to be ascribed to the induction of irregular action of capillaries, extending its morbific effects to other portions of the frame, than to any check given to the cutaneous transpiration.

"All that we have hitherto shown on the subject of perspiration will considerably facilitate our examination of a question which naturally presents itself. Is perspiration susceptible of being suppressed? It is easier to resolve this question witb regard to man and other warm-blooded animals, than with respect to the cold-blooded vertebrata. Let us see wbat is the result of a very low temperature upon warm-blooded animals. We know, by the effect of cold upon the sweat, that it diminishes transudation. Now let us suppose that it may, by its intensity, suppress it altogether, there will remain perspiration by evaporation which will always take place however humid the air may be. The high temperature of man and other warm-blooded animals, warms the air in contact with the body, and changes its hygrometric state by removing it from its extreme of humidity, and consequently occasions evaporation. If, on the other hand, the temperature of the air be raised to an equality with that of the body, at the time that it is saturated with humidity in order to suppress evaporation, then perspiration by transudation is excited, and takes place to such an extent in man and other warm-blooded animals, that the sweat will stream from all parts of the body. We can then in no case suppress their perspiration; it will be performed either by evaporation or by transudation. We ought therefore to be careful how we take literally what we find in medical books respecting suppressed perspiration. There can be no such thing. That there may be suppression of sweat, is evident to every one; but it does not follow that even in these cases there is no transudation.

"Since it is difficult to assure ourselves directly whether transudation is ever entirely suppressed in man and other warm-blooded animals, let us see what the cold-blooded vertebrata will offer on this point.

"The batrachians are the best adapted to this kind of researches, on account of the nakedness of their skin, of the fineness of its texture, of the copious loss which may be incurred through its medium, and consequently of the relation which their perspiration bears to that of man.

"On exposing frogs to the temperature of 0° cent. 32° Fahr. in humid air, in

order to suppress perspiration by evaporation, they have lost by transudation, in different experiments, the 30th part of their weight. Transudation is more abundant in these animals than in man, though the latter be placed in circumstances much more favourable. When we consider how sensible these creatures are to cold, how much the activity of all their functions is diminished at a low temperature, and how much they may even then lose by transudation, it is not to be supposed that cold suppresses this mode of perspiration in man, and the less so from his having a temperature of his own which varies very little with the changes of the atmosphere, a condition which has a powerful tendency to maintain transudation. It may be very much diminished by the action of cold but it appears that it cannot be altogether suppressed.

"It is a remarkable, but well-known fact, that when life is sinking, and to appearance nearly extinct, the body is covered with sweat—so strong is the tendency to continue this function."

Lastly, as the author has properly remarked, if the body were immersed in a denser medium than air—in water, for instance, supposing that it had no physiological action on the skin, it would merely prevent the contact of the air, and consequently suppress evaporation; but the vital action of the perspiratory vessels would continue, although we cannot think to the same extent, as in the air; but the deficient depuration would probably be made up by exhalation from the lungs and kidneys.

On the question, whether absorption of water takes place through the skin in man, M. Edwards is in the affirmative. He has no doubt, too, that it is readily effected when the body is placed in humid air. The experiments on this subject by Sanctorius, Seguin, Rousseau, &c. are sufficiently discrepant, but still we think enough has been done to demonstrate, that cuticular absorption is not easy; and that one of the great uses of the cuticle is to obviate the evils that might result, provided it were more readily effected. Yet the lizard, whose skin is scaly, after having lost weight by exposure to the open air, recovers its weight and plumpness when placed in contact with water, and if the scaly skin of the lizard permits such absorption, Dr. Edwards thinks it is impossible not to attribute this property to man.

The experiments of Seguin and Rousseau exhibit, as we have remarked, that this is by no means easy, but we can readily conceive, from the facility with which water soaks through animal tissues, that if the animal body be immersed sufficiently long in it, and especially if the vessels have been previously drained, imbibition might take place to a considerable extent, until a state of healthy fulness were induced. But this would be a mere mechanical, or physical absorption, and could be effected in the dead body as well as in the living.

In the chapter on *Temperature*, in which is investigated the degree of heat that man and animals can endure, the author does not offer any new results. He notices the well-known effects, such as the acceleration of the pulse, and of respiration, the feeling of greater or less heat, &c.

The power of maintaining the heat with but slight modifications, has been long admitted. The experiments of Sir Charles Blagden, Dr. Fordyce, Dr. Franklin, and others, had sufficiently established it. The greatest elevation was experienced by MM. Delaroche and Berger in their own persons. The temperature of the former was raised from 97°.8 to 106° by staying eight minutes in a stove, heated to 176° Fahrenheit. Experiments cannot, of course, be instituted on man to ascertain the highest degree his temperature can attain under the influence of excessive atmospheric heat; but M. Edwards considers, from the general results of experiments on warm-blooded animals, that he could not, under the influence of excessive heat, in a dry air, experience during life a higher rise of temperature than 12°.5 or 14° Fahrenheit.

The author assigns, with Delaroche and Berger, the agency of keeping down the temperature of animals, when exposed to heated air, to the evaporation which takes place from them. This, he thinks at least, would be sufficient, when the air has a temperatore above that of warm-blooded animals, "but below this limit it would be incorrect to attribute to this cause, as is generally done, the real or supposed power of man, and other warm-blooded animals, to maintain uniformity of temperature under the vicissitudes of seasons, and climates." p. 201.

On investigating the refrigeration or cooling in different media, at temperatures inferior to that of the body, M. Edwards found, as a general result, that the refrigeration was the same in humid as in dry air, whence it would follow, that the cold, produced by the greater evaporation in the dry air, was balanced by the cold resulting from the contact of the humid air. In air at rest, at a temperature inferior to that of the body, heat is lost in three ways; by evaporation, by contact, and by radiation. If the air be agitated, its radiation will not be affected; but the constant change of the air considerably increases the quantity of heat abstracted by contact, and this in a degree proportioned to the rapidity of the current. Evaporation is also augmented according to the velocity of the wind, and it is owing to these circumstances, that we have often a powerful sensation of cold, when the temperature may be the same, and the only change in the atmosphere may have been the greater velocity of its motion.

The fifteenth chapter contains novel and ingenious remarks *on the influence of light upon the development of the body.* Its influence on inorganic bodies and on vegetables being undoubted, M. Edwards conceived, that it might not be less manifested on animals. Its effect in producing those maniacal exacerbations, which occur at the full moon, and which have been generally ascribed to the direct agency of that luminary, is unequivocal. The *etiolation*, too, or blanching, perceptible in the countenances of the miner, and the civic resident, has been ascribed to its deficiency, but it is obviously difficult in these cases to distinguish the effect of the privation of light from other deleterious agencies that abound in such localities. Our author's attention was therefore directed to the effect of light on the development of animals; in other words, on those changes of form, which they undergo in the interval between conception and the adult age. He found, that absence of light manifestly retarded the transformation of the tadpole into the frog, and conversely that its presence favoured the development of form. His researches on this point led him to the following interesting and instructive inferences:—

"In the climates in which nudity is not incompatible with health, the exposure of the whole surface of the body to light will be very favourable to the regular conformation of the body. This application is confirmed by an observation of Alexander de Humboldt in his voyage to the equinoctial regions. Speaking of the Chaymas, he says: 'Both men and women are very muscular, their forms are fleshy and rounded. It is needless to add that I have not seen a single individual with a natural deformity. I can say the same of many thousands of Caribs, Muyscas, and Mexican and Peruvian Indians, which we have observed during five years. Deformities and deviations are exceedingly rare in certain races of men, especially those which have the skin strongly coloured.'

"On the other hand we must also conclude that the want of sufficient light must constitute one of the external causes which produce these deviations of form in children affected with scrofula, which conclusion is supported by the observation that this disease is most prevalent in poor children living in confined and dark streets. We may from the same principle infer that in cases where these deformities do not appear incurable, exposure to the sun, in the open air, is one of the means tending to restore a good conformation. It is true that the light which falls upon our clothes, acts only by the heat which it occasions, but the exposed parts receive the peculiar influence of the light. Among these parts, we must certainly regard the eyes as not merely designed to enable us to perceive colour, form and size. Their exquisite sensibility to light must render them peculiarly adapted to transmit the influence of this agent throughout the system, and we know that the impression, of even a moderate light, upon these organs produces, in several acute diseases, a general exacerbation of symptoms." p. 111.

The last chapter but one in the book is on the *Alterations in the*

Air from Respiration. On many topics, connected with this subject, much discordance has prevailed amongst observers. All, however, have remarked, that oxygen disappears, and carbonic acid is formed, but no agreement exists as to the mode in which these results are produced.

Two chief chemical hypotheses have been formed for this purpose. The one—that of BLACK, PRIESTLEY, LAVOISIER, and CRAWFORD—that the oxygen of the inspired air attracts carbon from the venous blood, and that the carbonic acid is generated by their union. The other, which has been supported by LAGRANGE, HASSENFRATZ, and others, that the carbonic acid is generated in the course of the circulation, and is given off from the venous blood in the lungs, whilst oxygen gas is absorbed.

The first section of the chapter in the work of M. Edwards is dedicated to an inquiry into the proportion of the oxygen that disappears to the carbonic acid produced. In Priestley's experiments, the latter seemed to have the preponderance. MENZIES, CRAWFORD, ALLEN and PEPYS, DALTON, PROUT, HENRY, and others, thought they were equal; LAVOISIER and SEGUIN estimated the oxygen, consumed in the twenty-four hours, to be 15661.66 grains; whilst the oxygen, required for the formation of the carbonic acid exhaled, was no more than 12924 grains; aud Sir HUMPHRY DAVY found the oxygen consumed in the same time to be 15337 grains; whilst the carbonic acid produced was 17811.36 grains; which would contain 12824.18 grains of oxygen.

The experiments of Edwards show, that the discordance has not depended so much upon the different methods and skill of the experimenters, as upon other causes. He found, on comparing the results of individual experiments, a great difference in the proportion of the oxygen absorbed to the carbonic acid produced, ranging between rather less than a half, and one-sixth, but the quantity of carbonic acid produced was very uniform, when the circumstances were similar. He found also, that the variation depends upon the particular animal species subjected to experiment; upon its age, or on some peculiarity of constitution, and that it differs greatly in the same individual at different times.

The disagreement of experimenters, regarding the exhalation or non-exhalation of azote from the air, during respiration, is even greater than in the case of oxygen. PRIESTLEY, DAVY, HUMBOLDT, CUVIER, THOMSON, and others, found a less quantity exhaled than was inspired. SPALLANZANI, LAVOISIER and SEGUIN, VAUQUELIN, ALLEN and PEPYS, ELLIS, and DALTON, inferred, that neither absorption nor

exhalation takes place,—the quantity of that gas undergoing no change during respiration; whilst Jurine, Nysten, Berthollet, and Dulong and Despretz found an increase in the bulk of the azote. The inferences of our author are, that in a large number of cases the azote inspired and expired so nearly approaches to equality, that the slight difference may be disregarded, and exhalation rejected; and, that in a great number of other cases, the excess of azote is so considerable, that the exhalation of this gas cannot be denied, inasmuch as the quantity greatly exceeds the volume of the lungs, and bears a large proportion to that of the animal. The causes of these variations appear to be numerous, and ascertainable with difficulty.

The experiments of M. Edwards with regard to the exhalation of carbonic acid, ready formed, from the lungs, are very decisive. Spallanzani had affirmed, that when certain of the lower animals, as snails, are confined in gases that contain no oxygen, the production of carbonic acid is uninterrupted. On the strength of this assertion, our author confined frogs in pure hydrogen for a length of time. The result indicated that carbonic acid was produced, and in such quantity as to show, that it could not have been derived from the residual air in the lungs, as it was in some cases equal to the volume of the animal. Indeed, it occasionally amounted to five or six per cent.—considerably exceeding the bulk of the animal. The absorption of a considerable portion of hydrogen was also noticed.

The experiments were repeated on fishes, snails, and on kittens two or three days old, with similar results.

With respect to the source of the carbonic acid, M. Edwards concludes, that both in hydrogen and in atmospheric air, the carbonic acid is owing to exhalation, and that it proceeds wholly or in part from the blood, which has been proved to contain carbonic acid by Vauquelin, Vogel, Brande, Sir Everard Home, and others. When blood is placed in hydrogen, it exhales carbonic acid.

The following general views of the alterations effected in the air by respiration is given by the author:—

"The oxygen which disappears in the respiration of atmospheric air is wholly absorbed. It is afterwards conveyed, wholly or in part, into the current of circulation.

"It is replaced by exhaled carbonic acid, which proceeds wholly, or in part, from that which is contained in the mass of the blood.

"An animal breathing atmospheric air also absorbs azote; this is likewise conveyed wholly, or in part, into the mass of the blood.

"The absorbed azote is replaced by exhaled azote, which proceeds wholly, or in part from the blood.

"Here are four fundamental points:

"1st. The absorption of oxygen which disappears.

"2d. The exhalation of carbonic acid which is expired.

"3d. The absorption of azote.

"4th. The exhalation of azote.

"The two first relate to the oxygen, the two others to the azote.

"According to this view, respiration is not a purely chemical process, a simple combustion in the lungs, in which the oxygen of the inspired air unites with the carbon of the blood, to form carbonic acid, to be expelled; but a function composed of several acts. On the one hand there are absorption and exhalation, attributes of all living beings; on the other the intervention of the two constituents of atmospheric air, oxygen and azote.

"This view is not a preconceived idea, but a result to which we have been necessarily led by a multitude of facts.

"It exhibits to us animated beings drawing from the composition of the atmosphere two of their constituent principles.

"It furnishes us with numerous inferences, several of which are supported by facts already received in science.

"Thus the oxygen which disappears being absorbed, and the carbonic acid exhaled, the relative proportions are necessarily variable, from the nature of the two functions which must vary in the extent of their action. The fact is beyond doubt. They may vary in three ways. 1. The carbonic acid may be expired in smaller quantity than the oxygen which disappears; 2, in equal quantity; 3, in excess. The first is the ordinary case; the second is supported by the experiments of Allen and Pepys; the third, if it is not yet established, will probably be so hereafter. I might even say that it is so already, when we revert to the experiment of Allen and Pepys, relative to respiration in factitious air, composed of oxygen and hydrogen. The same observation applies to azote absorbed and exhaled.

"Let us return to the oxygen, and consider what becomes of it in the system. When it is absorbed and carried into the blood, there is every reason to believe, that it contributes to the formation of carbonic acid. But the experiments which I have already detailed prove, that it cannot be the only source of the gas contained in the blood.

"Since we have shown, that certain species of animals can exhale in a given time, as much carbonic acid in hydrogen, as in atmospheric air, there must be one or more subsidiary sources for the carbonic acid contained in the blood. It is easy to point out one. We know, from the researches of Jurine, Chevreul, Magendie, and others, that this gas exists in almost the whole extent of the alimentary canal. We cannot but admit, that it is formed in the process of digestion. It is in contact with almost the whole mucous surface of the alimentary canal, and a part must be absorbed. If any doubt of this were entertained, cases might be cited in which water impregnated with carbonic acid, and drunk in sufficient quantity, has produced symptoms of asphyxia. Doctor Desportes has communicated observations on this subject to the Royal Academy of Medicine.

"With respect to the oxygen which is to contribute to the formation of the carbonic acid contained in the mass of the blood, one of two things must happen. It enters into combination either suddenly or slowly. In the latter case there will be oxygen in excess, circulating in the mass of the blood. This pure

oxygen will therefore be subject to exhalation, which will take place in the organs adapted for giving passage to it, as happens in fishes, in the air bladders of which animals oxygen is found. I propose following up this subject, and examining different kinds of blood, in conjunction with M. Dumas." p. 244.

Not the least important portion of Dr. Edwards's work is the concluding chapter, relative to the *applications* of the deductions arrived at from the experiments detailed in the previous chapters; and the first he makes regards the faculty of producing heat. This faculty was shown to vary during health, and it varies still more in a state of disease.

The phenomena presented by torpid animals, and by the mammalia, and birds that are not torpid, leads Dr. Edwards to infer, that during the state of *natural sleep* there is a diminution in the power of producing heat; so that the application of cold, a damp and cold air, or a dry and piercing wind, which could be borne with impunity in the waking state, may act most injuriously during sleep.

The natural sleep of hybernating animals, he thinks, merits the denomination of *lethargic sleep*, from the remarkable diminution of temperature, respiration, and circulation, as well as of the external motions, and excitability of the senses, but similar changes he conceives may take place in man, so as to render his sleep lethargic, and he is disposed to believe in the instances of this kind of lethargic sleep, detailed in medical works,—affirms, indeed, that his own experience has convinced him that such cases do occur. We wish M. Edwards had detailed the cases. The instances of trance, lethargy, &c. of which there are so many on record, have certainly appeared to us sufficiently marvellous, and it would take all the weight of M. Edwards's facts and authority to alter our opinions upon the subject. At one time, it was universally believed, that substances could be administered, which might arrest the whole of the vital functions, or cause them to go on so obscurely as to escape detection, a notion which is embraced by Shakespeare, in his *Romeo and Juliet:*—

"Take then this phial,
And this distilled liquor drink thou off;
When presently through all thy veins shall run
A cold and drowsy humour, which shall seize
Each vital spirit, for no pulse shall keep
His natural progress, but surcease to heat.
No warmth, no breath shall testify thou livest,
The roses in thy lips, and cheeks shall fade
To paly ashes; the eyes windows fall
Like death, when he shuts up the day of life;
And in this borrow'd likeness of shrunk death,
Thou shalt continue two-and-forty hours,
And then awake as from a pleasant sleep."

No one, however, at the present day, believes in the existence of any such medicament.

2. In his second "application," he assimilates the effect produced upon young animals by refrigeration, to the defective power of producing heat in the *febres intermittentes algidæ*, described by TORTI, in which the power is so far impaired, that the patient dies in the cold stage, at the end of two or three paroxysms, if suitable remedies be not employed.

"3. Since the application of external heat tends to reänimate the power of producing it, this means may be substituted for the extraordinary efforts of the system, which tend to the same object. It may be done either to prevent them, or to shorten their duration."

4. From the experiments, connected with dry and moist air, he considers, that damp cold must tend to produce, in individuals whose power of developing heat is rather feeble, the series of actions which constitute the accession of an intermittent fever, especially if they are exposed to that influence during sleep. Such a state of the atmosphere is, indeed, a great exciting cause of intermittents, provided a predisposition exists, derived from a malarious locality, but without this predisposition, the exciting cause might be applied in vain. In many parts of every country intermittents are unknown, notwithstanding the prevalence of winds of the character described.

5. Dr. Edwards transfers his results, connected with the influence of the seasons on the production of heat, to the question of the influence of climates, and as the animals, in his experiments, appeared to exhibit a summer and a winter constitution, he compares the former with that of the inhabitants of warm climates, and the latter with that of the inhabitants of cold climates; "but there will be this difference, that the modification which characterizes the summer constitution in our climate, will be much more strongly marked in warm climates."

Now, in individuals whose constitution is suited to the climate, there is a diminution of the power of producing heat in summer, and an increase in this respect in winter, whence he concludes, that this power will be feebler in the inhabitants of warm, than in those of cold climates, and consequently, when they change their climate, they must be, in general, less capable of supporting the cold, than the natives of the country.

6. In warm climates, a remedy is found for the excessive heat, in the increased evaporation which takes place, but its influence is considered to be exaggerated, when it is supposed that an exact compensation can be effected by it.

7. Does the temperature of man and of warm-blooded animals

vary according to the season? The general belief has been, that it is constant in the state of health and in ordinary circumstances, notwithstanding the heats of summer and the colds of winter. From several experiments, however, tried by our author on yellow-hammers and sparrows, at different periods in the course of the year, it would result, that the averages of their temperature ranged progressively from the depth of winter to the height of summer, within the limits of 5° or 6° Fahrenheit: and the contrary course was observed in the decline of the year. Hence he iufers, and with every reason in his favour, that the temperature of man experiences a similar fluctuation.

8. The human temperature is rarely raised beyond 106° Fahrenheit, in the hottest of all diseases, scarlatina. Dr. James Gregory, of Edinburgh, used to assert, that he doubted the accuracy of the thermometer when a higher temperature was indicated. M. Edwards alludes to a case of tetanus, communicated to him by M. Prevost, of Geneva, in which the temperature rose to 110°.75 Fahrenheit; so that if the healthy temperature of the child was 98°.2, here was a rise of 12½°, Fahrenheit.

9. To reduce this excessive heat, external agents of a suitable temperature are most effectual: damp cold, of all external means of refrigeration, tends best to diminish the activity with which heat is developed. Hence its value as a refrigerant in fevers, now universally acknowledged.

10. But if damp cold cannot be sufficiently prolonged, sponging with water of any temperature, provided it be not excessively hot, occasions a more abundant evaporation, and a salutary refrigeration, the effect of which is extended to other parts of the frame, by virtue of the extensive sympathy that exists between all parts of the capillary surface.

11. When the ventilation of an apartment is properly attended to, the quantity of heat is diminished, both by the contact of fresh portions of air, and by increased evaporation.

12. Excessive evaporation is injurious to man. The distress, experienced in the higher regions of the atmosphere—on the tops of mountains, or in balloons—is rather owing to this cause, perhaps, than to the rarefaction of the air, although the latter has its effects. In the celebrated aerial voyage of Gay Lussac, he found that the air contained, at the height of 23,000 feet, only one-eighth of the moisture necessary for its saturation. Owing to this cause, such an increase of evaporation takes place from the dermoid surface, under these circumstances, that the loss of fluid occasions a sensation of distress in the chest, proportionate to the desiccation.

"If, as frequently happens upon mountains, the weatber change quickly, loading the air with bumidity, the evaporation becomes moderate and the distress diminishes, or ceases entirely. If it still continue it is owing to the rarefaction of the air. The effect of evaporation is felt the first, and that which is owing to a want of air comes long after: it requires even a mueh greater height to produee it than one would be inelined to believe wben the two sensations are confounded.

"Thirst is a symptom wbieh attends the ascent of mountains. It is sometimes intense, when it eannot be ascribed to the fatigue of exereise. It is only momentarily satisfied, even by abundant and often repeated draughts. But if the air becomes eharged with moisture, the thirst at the same time disappears. Here is an example perfectly analagous to that which we have elsewhere mentioned as tbe effeet of a partial desiecation, although the body may be furnished with a suffieient quantity of water to prevent its losing its total weight, the distribution of the liquid to tbe different part not being in suffieient proportion to repair local loss. It is obvious that this influenee will be very differently felt by different individuals, aeeording to the state of the lungs." p. 260.

13. Dr. Edwards alludes to a symptom, connected with respiration limited by rarefaction of the air, which has not been usually noticed—a disposition to vomit. This has been observed during the ascent of great heights, and the author thinks the symptom, thus induced, may be connected with a great many others, in which respiration is limited in various ways, as in acute or chronic congestion of the lungs, "when the disposition to vomiting, and vomiting itself, are frequently symptoms arisIng frum the diminution of the communication of the system with the air."

14. Species and individuals vary greatly in their power of supporting limited respiration. It would not seem, that the limits, at which extreme rarefaction produces effects almost as rapid as those of the absolute privation of this fluid, differ greatly in warm-blooded animals. The pressure at which yellow-hammers were on the point of dying, corresponded, taking the average, to 5.31 inches of the barometer; the average for Guinea pigs, to 3.58 inches; and these animals presented the extreme results.

15. Facts, connected with excessive evaporation from the lungs, are observed in other than elevated regions. When, during a very sharp cold in winter, a room is warmed by means of a stove, a painful sensation in the chest is experienced by many. The air, in a frost, contains scarcely any watery vapour, and the heat of the stove, by raising the temperature of the air, increases its capacity for vapour, so that, at an equal temperature, the quantity of liquid dissipated by evaporation is much greater than in summer. To remedy this, in some

measure, we are in the habit of placing a vessel of water upon the stove, and it is advantageous.

"In arid districts," says M. Edwards, "effects are ascribed to the heat of the air and of the wind, which arise, in a great degree, from the evaporation occasioned by the dryness of the atmosphere. Dr. Knox, who travelled in the interior of Africa, to the north of the Cape of Good Hope, has related to me facts, which justify this opinion." p. 263.

16. In an agitated atmosphere, not extremely humid, evaporation, as a general rule, may be as great as in a calm and dry air; but if we suppose two states of the atmosphere in which the effects of motion in the one would equal those of dryness in the other, their respective influence upon evaporation would not be the same.

"Air in motion only acts upon exposed surfaces, as the integuments of the body; those of the lungs are sheltered, and notwithstanding their communication with the atmosphere, the agitation of the air has but a slight share in the quantity of vapour which they furnish. This consideration will serve to determine the choice of suitable places for the residence of delicate persons. Those to whom the increase of evaporation from the lungs is injurious, ought to prefer an atmosphere less dry, but slightly agitated, when it is important to obtain an agreeable freshness." p. 264.

17. To remedy the dryness of the skin, and air passages, which acts most prejudicially, in the opinion of the author, in a great number of acute diseases, and for which drinking is insufficient, the atmosphere ought to be rendered moist by a sufficient evaporation of water, by which means the desiccation of the respiratory organs may be arrested.

18. The author properly inculcates the necessity of guarding children against the injurious impressions of cold in cold climates and seasons, by appropriate clothing, and he ascribes much mischief to a neglect of these precautions. Although the want of warm clothing is actually felt, its use is often declined from a wish to reserve it for an advanced age; but our author thinks it frequently happens, that this very precaution is the cause of preventing that age from being attained.

19. Clothing is insufficient to preserve the heat so as to maintain the existence of very young animals, and of infants born about the period when they begin to be *viable* or rearable. The continued external application of heat is demanded, until the body has acquired sufficient development; and the same remarks are applicable to every period of life, when the constitution, from any cause, approximates to the modification in question.

20. This "*application*" treats specially of the effects attributed to

suppression of perspiration, of which we have already expressed our opinion.

21. If we compare the daily average of meats and drinks, during the course of a year, with the sum of all the losses by perspiration, and the alvine and urinary evacuations, it will be found that they are nearly the same. On taking the average results of observers, it is found that the proportion of urine to perspiration is, on the whole, about 1 to 1.08. The alvine evacuation forms but a small portion of the total loss, the mean of all the tables being four ounces.

"By subtracting this quantity from the sum of the meats and drinks, and taking the half of the remainder, we shall have an approximate result of the mean product of the perspiration of a day in the course of the year. In order to judge of the degree of approximation which may be attained, by making use of these data with the mere knowledge of the sum of meats and drinks, we give the comparison of the results furnished by experience, with those deduced by calculation from the preceding proportions.

"*Mean Losses by Perspiration in a Day.*

	Robinson. 42 yrs.	Robinson. 64.5 yrs.	Keill. 39 yrs.	Rye. 42 yrs.	Lining. 40 yrs.
By observation,	45 oz.	27 oz.	30 oz.	56 oz.	60 oz.
By calculation,	41	27	35	46	62

It is found, that in temperate climes the mean perspiration in summer exceeds the urine; whilst in winter the contrary holds good. In warm climates the average of perspiration for the year doubtless exceeds the average of the urine.

22. M. Edwards lays great stress upon the effect of slight agitation of the air, when the hygrometric state and temperature are adapted to the system: the chest, under such circumstances, dilates, and admits a large proportion of air; and he thinks that persons who have what is called delicate lungs, may owe in a great degree the difficulty and oppression which they feel to the smallness of their apartments; as the difficulty decreases on going into a large room, or into the open air; and he affirms, that whatever difference of purity may be attributed to the air of small and of large towns, of narrow and of wide streets, of town and of country, the degree of agitation of the air has the most marked influence on the extent to which the chest dilates; and the agreeable sensation, which is experienced on breathing in the country is principally due, he conceives, to that cause.

24. As young animals bear a limited respiration better than adults, he infers, that children, in whom respiration may be limited by engorgement of the lungs, will, *cæteris paribus*, be in less danger than adults, in whom respiration may be limited in like manner, and to

the same degree, and as the disturbance of the system, indicated by the acceleration of respiration, circulation, &c. is so much the greater as the want of air is the more pressing, the symptoms of pneumonia will be more intense in adults, in cases in which the relative extent of disease is equally limited.

25. If, therefore, an individual be affected with pneumonia, so far as to endanger his life by diminished communication with the air, the most urgent indication will be to employ the best means for bringing back his constitution to that state which would enable him to support his limited respiration. For this purpose, blood enough must be abstracted to diminish the power of producing heat, and keep it within the limits compatible with life. The more serious the case, the greater ought to be the abstraction of blood. Such is the author's theory. We would inculcate the same practice, under the obvious indication that the inflammation must be got under, otherwise it will run on to disorganization and death.

Some other *applications* are given by M. Edwards, but they are mostly speculative, and not as pregnant with interest or novelty as those we have considered.

The following remarks in his concluding application are, however, important.

"We find in the changes which the blood can undergo as to its composition, a fertile source of the changes in the mode of vitality. It would appear at first that it is only through this medium that we can act on the nervous system, in order to modify its action so as to change the constitution of individuals; on account of the extent in which this fluid can vary, and of the apparent immutability of the nervous system in its form and structure.

"It is evident, that the dimensions and proportions of that system have limits assigned by nature to the modifications which their vitality can undergo; it is, however, susceptible of considerable changes, not discernible by inspection, but which manifest themselves by the actions which result from them, and which do not arise from the influence of the blood. Such effects may, as we have formerly proved, be produced by temperature, by light, electricity, and a number of other influences by contact to say nothing of moral causes. It is this which I have had in view in speaking of the special action of the air on the system, and which I have designated vivifying influence.

"It is thus that the impression of the air serves to reänimate a life almost extinguished in the case of apparent death, and here man has an advantage over all warm-blooded animals, even the hybernating. Their skin, covered with hair or feathers, is less accessible to the air; and I have never seen an adult individual which, after the cessation of all external motion by submersion in water, has been recalled to life by exposure to the air. Man, on the contrary, whose skin is bare, delicate, and sensible, may be reänimated by the action of the air, when he appears to have lost, under water, sense and motion.

"We have shown elsewhere, that new-born children, when deprived of air, would not give signs of life during so long a space of time as young mammalia

of the same age, which are born with closed eyes; they will, however, more easily recover from apparent death, because their skin is adapted to receive a stronger impression from the air.

"We have seen how fatal heat is in cases of asphyxia, and of very confined respiration. Now, when the action of the air is reduced to the effects which it produces upon contact with the skin, its influence is the weakest possible, and at first it cannot easily be conceived what advantage can be derived from the application of heat. If that application be of long duration it will be fatal; in some cases it may be useful if it is of short duration. When an animal is plunged in water at the temperature of 40° cent. or 104° Fahr., its motions are much more forcible, but less numerous than at inferior temperatures. There are circumstances, then, in which heat may be momentarily applied in order to excite the movements of the chest. The immersion of a great part of the body in warm water, is frequently an efficacious means of reänimating a child just born without signs of life. As soon as motion is produced, or if it be slow in manifesting itself, it will be right to abandon a method, the prolonged use of which, would be fatal.

"We must, therefore, look upon the vivifying influence of the air in two points of view, its direct action on the nervous system by contact; and its action on the blood by the changes which it produces in it. In like manner, the vitality of individuals may be modified by a number of other causes which act immediately, either on the nervous system, or on the blood. Many facts mentioned in this work, are examples of both modes of action."

We have thus endeavoured to lay before the reader a full and clear analysis of the topics embraced in the original work of Dr. Edwards, as well as in the version before us. No one can witness the labour and research bestowed by the author without being impressed with his preëminent qualifications as an experimental physiologist, and without according with the encomiastic remarks of Dr. Hodgkin.

"Some minds," he observes, "are so happily constituted as to have a remarkable readiness in perceiving the relations which connect facts and observations, which to others appear not merely isolated, but absolutely contradictory. This appears to be particularly the case with Dr. Edwards. The labours of his predecessors had accumulated a vast collection of invaluable facts and observations, many of which seemed to be almost annihilated by their standing in direct opposition to others supported by equally valid and respectable authority: the labours of Dr. Edwards have explained many of these discrepancies. It may be ill-becoming in me to anticipate the judgment of the reader, but I cannot refrain from expressing my admiration of the patient and clear induction with which the doctor proceeds, step by step, through the great variety of subjects comprised in his work, so as to maintain the unity and connexion of the whole, and of the happy art with which he has both availed himself of the experiments and observations of his predecessors, and supplied the breaks and deficiencies which he met with, by well-contrived, simple, and conclusive experiments of his own." Preface, p. v.

The appendix to the work by the translators, consists of various papers by Dr. Hodgkin and other individuals. The first is on *Elec-*

tricity, by MM. Prevost and Dumas, and comprises a detailed account of their views regarding muscular contraction, which were briefly explained in a late number of this Journal.* The second is by Dr. Edwards, and is "*On Muscular Contractions produced by bringing a Solid Body into contact with a Nerve without a Galvanic Circuit.*" It has been long known, that when nerves and muscles are exposed in a living animal, and brought into contact, contractions or convulsions occur in the muscles. The experiments of Galvani, Volta, Aldini, Pfaff, Humboldt, and others, had satisfactorily established this. In the experiments of M. Edwards, the same effect was produced by touching a denuded nerve with a slender rod of silver, copper, zinc, lead, iron, gold, tin, or platina, and drawing it along the nerve for a space of from a quarter to a third of an inch. He took care to employ the metals of the greatest purity, and as they were supplied to him by the assayers of the mint. But it was not even necessary that the rod should be metallic, he succeeded with glass or horn. "To produce muscular contraction it is sufficient that the nerve be touched with any solid body in the manner above related." All these metals, however, did not produce equally vigorous contractions. Iron and zinc were far less effective than the others, but no accurate scale could be made of their respective powers.

Much difference is found to exist when electricity is employed, according as the nerve is insulated or not, for as the muscular fibre is a good conductor of electricity, if the nerve be not insulated, the electricity is communicated to both nerve and muscle, and its effect is consequently diminished. It became interesting to know, whether any difference would be produced, when one metal only is used, if the nerve be insulated or not. In the experiments, above referred to, the nerve was insulated by passing a strip of oiled silk beneath it. A comparison was now made between an animal so prepared, and another in which the nerves, instead of being insulated, reposed on the subjacent flesh.

"I made use," says M. Edwards, "of small rods, with which I easily excited contractions, when I drew them from above to below, along the portion of denuded nerve, which was supported by the oiled silk; but I was unable to excite them, when I passed them along the nerve of the other animal, in which they were not insulated. Frequent repetitions assured me, that the want of effect did not depend on difference in the degree of contact: I tried the experiment on many animals of the same species, lest there might be any thing in individual peculiarity. As in the one case the nerves were brought further into view, and kept somewhat tense and even with the sacrum, by means of the slip of oiled silk,

* Number XXIII. for May, 1833, p. 144.

whilst in the other they had no such support, I restored the parity of position, by placing under the unsupported nerves, a portion of muscle, corresponding to the slip of oiled silk, as well in size as mode of insertion, and still was unable to produce contractions by treating the uninsulated nerve, whatever was the material of the rod employed as the exciter. The difference was rendered still more striking, when instead of making the comparison between two individuals, it was made upon the same animal. After having in vain attempted to produce contractions by contact of a nerve resting upon muscle, I found that they might still be induced, if the oiled silk were had recourse to, and I was able to command their alternate appearance and disappearance, by using sometimes a non-conductor, and at others, a conductor for the support of the nerve." p. 313.

Somewhat surprised at these results, our author was stimulated to the investigation—whether some degree of contraction might not be excited by touching the uninsulated nerve? and, having observed, that in the insulated nerve contractions were most constantly produced by a quick and light touch, he adopted this method in an animal whose nerve was not insulated, and frequently obtained slight contractions.

All his experiments on this matter seemed to prove satisfactorily, that, *cæteris paribus*, the muscular contractions produced by the contact of a solid body with a nerve, are much less considerable, or even wholly wanting, when the nerve in place of being insulated, is in communication with a good conductor; "and it would seem to follow, as a legitimate conclusion, that these contractions are dependent on electricity;" facts, which it is highly necessary to bear in mind, in all experiments on animals, where feeble electrical influences are employed.

On the remaining selected articles we cannot dwell. The length to which this review has already extended, precludes us. We may merely remark, that in the article on *atmospheric electricity*, by Pouillet, the author ascribes its origin greatly to the changes effected during vegetation, and to the evaporation from the surface of the sea, which forms, in his opinion, one of the most important sources. Signs of electricity are produced by evaporation from an alkaline solution, but not from mere evaporation, whether rapid or slow. Lakes and rivers are, however, presumed to have their influence, since their waters are never perfectly pure, but contain alkaline impregnations.

The remaining papers consist of an extract from an *Essay on some of the Phenomena of Atmospheric Electricity*, by Luke Howard, F. R. S., which was published thirty-four years ago, with remarks on the same subject by the editor, (Dr. Hodgkin,) and experiments and observations by C. Woodward and P. Smith: Dr. Hodgkin's Inaugural Essay—*De Absorbendi Functione*—a fair specimen of such

essays, but not worthy perhaps of republication, in the same form, at least; with further remarks on the same subject, by the author: *On the Phenomena to which the names Endosmosis and Exosmosis have been given by* Dutrochet: *On the Microscopic Characters of some of the Animal Fluids and Tissues*, by J. J. Lister and Dr. Hodgkin; and lastly a "juvenile essay," by Dr. Hodgkin, *on the Uses of the Spleen*, published in the *Edinburgh Medical and Surgical Journal*, January, 1822; in which he regards, with others, the spleen as a diverticulum, and as fulfilling an office in the animal system, similar to that of tubes and valves of safety, in various kinds of chemical and mechanical apparatuses.

Many of these subjects have been noticed in the pages of this journal, and although the author's sentiments are manifestly regarded by him to be full of important bearings, we have strong doubts whether the physiological world will think them equally so. His microscopical researches have certainly destroyed the idea of the beautiful harmony and simplicity, that appeared to prevail in organized existence, from the microscopic researches of Dr. MILNE EDWARDS, who found, that "spherical corpuscles, of the diameter of $\frac{1}{300}$th of a millimeter, constitute by their aggregation, all the organic textures, whatever may be the properties, in other respects, of those parts, and the functions for which they are destined."

Under this view of Dr. Edwards, it followed, of necessity, that all organized bodies possess the same elementary structure, and that the animal and the vegetable are readily convertible into each other, under favourable circumstances, and differ only in the greater or less complexity of their organization. The globular tissue is asserted by Dr. Hodgkin to be a mere illusion, and we have again to refer the most minute parts of the cellular membrane, muscles and nerves, to the striated or fibrous arrangement.

In the notes, p. 483, we have the old claim of Dr. STEVENS—that he suggested to Drs. FAUST and MITCHELL their important experiments on the penetrativeness of gases, vindicated by Dr. Hodgkin; but on this we have already expressed our sentiments.*

With respect to the execution of the translation it is but moderate. Due attention has not been paid to the correction of the proofs; the verbal mistakes are numerous, and throughout the first portion of the work, the thermometric calculations are given in degrees and minutes; 33° 8′ for example, being written for 33°.8. Especial care should have been paid to prevent such mistakes, in a work whose great value i its accurate experimental details and estimates. R. D.

* American Journal of the Medical Sciences, for May, 1833, p. 201.